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On the determination of the relative sign of a_1 and a_2 from polarization measurements in $B_u^- \rightarrow \rho^- D^{*0}$ decay.

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Abstract

We point out that polarization measurements such as the longitudinal fraction and the transverse left-right asymmetry in the Bauer-Stech-Wirbel (BSW) class III processes involving two final vector mesons, $B^- \rightarrow \rho^- D^{*0}$ taken as an example, are useful in determining the relative sign as well as the relative magnitudes of the coefficients a_1 and a_2 .

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I. Introduction

During the last few years, there has been considerable interest [1 - 7] in the determination of the phenomenological free parameters a_1 and a_2 introduced by Bauer, Stech and Wirbel (BSW henceforth) [8] in B meson decays. From a phenomenological point of view, there is no constraint on these parameters. We take them as free parameters to be determined from experiments.

However, there are some ambiguities in the sign of a_2/a_1 in B meson decays. Among two possible solutions, positive or negative sign for a_2/a_1 as was found in Ref.[1], recent CLEO II data [4, 6, 7] indicate that a_2/a_1 is positive.

In this paper, we suggest a new method to determine the size and the sign of a_2/a_1 . Since the decay amplitudes of the Class III depend on both a_1 and a_2 , measurements of the longitudinal polarization fraction and the left-right asymmetry in transverse polarization for $B^- \rightarrow \rho^- D^{*o}$, which has a sizeable branching ratio, can provide a way to settle the question.

1•) We start by recalling the relevant effective weak Hamiltonian :

$$\mathcal{H}_{eff} = \frac{G_F}{\sqrt{2}} V_{cb} V_{ud}^* [C_1(\mu) \mathcal{O}_1 + C_2(\mu) \mathcal{O}_2] + H.C. \quad (1)$$

$$\mathcal{O}_1 = (\bar{d}\Gamma^\rho u)(\bar{c}\Gamma_\rho b), \quad \mathcal{O}_2 = (\bar{c}\Gamma^\rho u)(\bar{d}\Gamma_\rho b) \quad (2)$$

where G_F is the Fermi coupling constant, V_{cb} and V_{ud} are the relevant Cabibbo-Kobayashi-Maskawa (CKM) matrix elements and $\Gamma_\rho = \gamma_\rho(1 - \gamma_5)$.

The Wilson coefficients $C_1(\mu)$ and $C_2(\mu)$ incorporate the short-distance effects arising from the renormalization of \mathcal{H}_{eff} from $\mu = m_W$ to $\mu = O(m_b)$. These coefficients are known to next-to-leading order (NLL) [10, 11].

In the leading-logarithm approximation (LLA) [12], we have

$$C_1 = \frac{1}{2} (C_+ + C_-), \quad C_2 = \frac{1}{2} (C_+ - C_-) \quad (3)$$

with

$$C_\pm = \left[\frac{\alpha_s(\mu^2)}{\alpha_s(M_W^2)} \right]^{\frac{2\gamma_\pm}{b}} \quad (4)$$

where $\gamma_- = -2\gamma_+ = 2$, and $\alpha_s(\mu^2)$ is the running coupling constant of the strong interaction given by

$$\alpha_s(\mu^2) = \frac{4\pi}{b \log(\mu^2/\Lambda_{QCD}^2)} \quad \text{with} \quad b = 11 - \frac{2}{3} n_f \quad (5)$$

where n_f being the number of 'active' flavours and μ is the typical mass scale of the problem.

With $\mu = m_b = 5$ GeV, $n_f = 4$ and $\Lambda_{QCD} = 0.25$ GeV, we have

$$C_1(\text{LLA}) = 1.11, \quad C_2(\text{LLA}) = -0.26 \quad (6)$$

Including next-to-leading log corrections one obtains [13]

$$C_1(\text{LLA} + \text{NNL}) = 1.13 \quad C_2(\text{LLA} + \text{NLL}) = -0.29 \quad (7)$$

i.e. a very mild enhancement of the original charged current coupling together with an induced neutral current operator with moderate strength.

After Fierz transformation, \mathcal{O}_1 and \mathcal{O}_2 can be written as [14]

$$\mathcal{O}_1 = \frac{1}{N_c} \mathcal{O}_2 + 2\tilde{\mathcal{O}}_2 \quad \tilde{\mathcal{O}}_2 = (\bar{d}\Gamma^\rho \frac{\lambda^a}{2} b)(\bar{c}\Gamma_\rho \frac{\lambda^a}{2} u) \quad (8)$$

$$\mathcal{O}_2 = \frac{1}{N_c} \mathcal{O}_1 + 2\tilde{\mathcal{O}}_1 \quad \tilde{\mathcal{O}}_1 = (\bar{d}\Gamma^\rho \frac{\lambda^a}{2} u)(\bar{c}\Gamma_\rho \frac{\lambda^a}{2} b) \quad (9)$$

where $N_c = 3$ is the number of colours and the second terms, $\tilde{\mathcal{O}}_1$ and $\tilde{\mathcal{O}}_2$, sometimes called non-factorizable terms, are composed of two color-octet currents with λ^a being the colour SU(3) Gell-Mann matrices.

We can rewrite Eq.(1) in two ways

$$\begin{aligned} C_1\mathcal{O}_1 + C_2\mathcal{O}_2 &= a_1\mathcal{O}_1 + 2\tilde{\mathcal{O}}_1 \\ &= a_2\mathcal{O}_2 + 2\tilde{\mathcal{O}}_2 \end{aligned}$$

where

$$a_1 = C_1 + \xi C_2 \quad a_2 = C_2 + \xi C_1 \quad \text{with} \quad \xi = \frac{1}{N_c}. \quad (10)$$

Assuming factorization, the matrix element for \mathcal{H}_{eff} for $B^- \rightarrow D^{*o}\rho^-$ is written as

$$\begin{aligned} \langle D^{*o}\rho^- | C_1\mathcal{O}_1 + C_2\mathcal{O}_2 | B^- \rangle &= a_1 \langle \rho^- | \bar{d}\Gamma^\rho u | 0 \rangle \langle D^{*o} | \bar{c}\Gamma_\rho b | B^- \rangle \\ &+ a_2 \langle D^{*o} | \bar{c}\Gamma^\rho u | 0 \rangle \langle \rho^- | \bar{d}\Gamma_\rho b | B^- \rangle. \end{aligned} \quad (11)$$

The contribution of the colour-octet currents vanishes in this approximation due to colour conservation.

In fact, we can rewrite \mathcal{H}_{eff} in terms of "factorized hadron operators" as [8]

$$\mathcal{H}_{eff} = \frac{G_F}{\sqrt{2}} V_{cb}V_{ud}^* \{ a_1 [\bar{d}\Gamma^\rho u]_H [\bar{c}\Gamma_\rho b]_H + a_2 [\bar{c}\Gamma^\rho u]_H [\bar{d}\Gamma_\rho b]_H \} + H.C. \quad (12)$$

where the subscript H stands for *hadronic* implying that the Dirac bilinears of Eq.(12) be treated as interpolating fields for the mesons and no further Fierz-reordering need be done.

The contribution of the non factorizable term may have a significant effect[‡] : in fact, this term might cancel a part of the factorizable one, more precisely that proportional

[‡]For a nonfactorizable contribution to exclusive nonleptonic weak decays, see for example Ref.[15]

to ξC_1 so that $a_2 \simeq C_2(\xi \simeq 0)$. Such cancellation seems to take place in charm two body decay [8], however it is an open question in B meson two body hadronic decays. Moreover, the rule of discarding the contribution of the operators with coloured currents while applying the vacuum saturation is ambiguous and unjustified. It has, therefore, been suggested that constants a_1 and a_2 be taken as free parameters.

2•) While in the charm quark sector, a negative value of a_2 corresponding to $N_c \rightarrow \infty$ is favoured by experimental data [8], for the b quark sector, an analysis [1] of the combined 'old data' from ARGUS and CLEO I yielded two possible solutions (positive/negative value) for a_2 when simultaneous fits were made to Class I, II and III data :

$$\begin{aligned} \text{(i)} \quad a_1 &= 1.10 \pm 0.08, & a_2 &= 0.20 \pm 0.02 \\ \text{(ii)} \quad a_1 &= 1.14 \pm 0.07, & a_2 &= -0.17 \pm 0.02 \end{aligned}$$

However, the recent CLEO II data on the B decays $\overline{B} \rightarrow D\pi(\rho), D^*\pi(\rho)$ exhibit a striking result [2, 4, 6, 7]: the interference between the two different amplitudes contributing to exclusive two-body B^- decays is evidently constructive, in contrast to what is naively expected from the leading $1/N_c$ expansion [8].

Refs.[4], [6] and [7] show that the sign of a_2/a_1 is positive, contrary to what is found in charm decays :

$$\begin{aligned} & 0.25 \pm 0.07 \pm 0.05 & [4] \\ \frac{a_2}{a_1} &= & \\ & 0.23 \pm 0.04 \pm 0.04 \pm 0.10 & [6, 7] \end{aligned}$$

However Ref.[5] show that the question of the magnitude and the relative sign between a_2 and a_1 is still uncertain when one standard deviation data are used. When data are taken only with two standard deviation, we found that a_2 is positive.

Faced with such uncertainties, we would like to suggest that precision polarization measurements in $B \rightarrow D^{o*}\rho^-$ can settle the question of the sign and the magnitude of a_2/a_1 .

II. Generalities

We start by describing our calculational procedure and parameters used.

1•) We assume factorization [8].

2•) We disregard the effect of final state interactions (FSI) in this paper. On physical grounds FSI effects are expected to be small as the produced quarks, being extremely relativistic, leave the strong interaction region before hadronization so that FSI between hadrons may not play a significant role. Ref.[3] provides an estimate of the strong interaction phase angles which turn out to be small.

3•) Parameters we use are [4, 6]

(a) $f_{\rho^+} = 212 \text{ MeV}$ which is measured from $\tau \rightarrow \nu_\tau \rho$ decay.

(b) $f_{D^*} = 220 \text{ MeV}$ which comes from theoretical estimates.

4•) We introduce the following dimensionless quantities :

$$r_D \equiv \frac{m_{D^*}}{m_B} \quad , \quad t^2 \equiv \frac{q^2}{m_B^2} \quad (13)$$

$$k(t^2) = [(1 + r_D^2 - t^2)^2 - 4r_D^2]^{1/2} \quad (14)$$

where $q^2 = (P_B - p_{D^*})^2$ is the square of ρ -meson momentum.

5•) The other theoretical inputs in our calculation are the hadronic form factors for $B \rightarrow D^*$ and $B \rightarrow \rho$ transitions for which we use various models. Here we use the BSW definition of hadronic form factor [8] :

5•-A) $B \rightarrow D^*$ transition in spectator mode

The spectator amplitude (\mathcal{A}), multiplied by the parameter a_1 , involves $B \rightarrow D^*$ hadronic form factors which correspond to heavy to heavy quark transition. We shall consider the following two models of form factors :

(a) The set HQET I associated with exact heavy quark symmetry and used, for example, by Deandrea et al. [9] in their analysis. An extrapolation of the Isgur-Wise function $\xi(y)$ is made from the symmetry point using an improved form of the relativistic oscillator model as described in [16].

(b) The set HQET II associated with heavy quark symmetry including mass corrections as proposed by Neubert et al [1]. We have made an interpolation of the entries in Table 4 of [1] to obtain the form factors needed.

The decay amplitudes, apart from an overall factor, for the three polarization states are given by

$$\begin{aligned} \mathcal{A}_{LL}(q^2) &= \frac{f_\rho}{m_B} \left(\frac{1 + r_D}{2r_D} \right) \{ (1 - r_D^2 - t^2) A_1^{BD^*}(q^2) - \frac{k^2(t^2)}{(1 + r_D)^2} A_2^{BD^*}(q^2) \} \\ \mathcal{A}_{\pm\pm}(q^2) &= \frac{f_\rho}{m_B} t (1 + r_D) \{ A_1^{BD^*}(q^2) \mp \frac{k(t^2)}{(1 + r_D)^2} V^{BD^*}(q^2) \} \end{aligned} \quad (15)$$

5•-B) $B \rightarrow \rho$ transition in colour – suppressed mode

The colour-suppressed amplitudes (\mathcal{B}), multiplied by the parameter a_2 , involve $B \rightarrow \rho$ hadronic form factors which correspond to heavy to light quark transition.

We shall consider here three sets of form factors :

(a) The set BSW II which is a slightly modified version of BSW I used in [1].

The normalization at zero momentum transfer and the pole masses are unchanged, however, the form factors $F_0^{B\rho}$ and $A_1^{B\rho}$ have a monopole type while the form factors $F_1^{B\rho}, A_0^{B\rho}, A_2^{B\rho}$ and $V^{B\rho}$ have a dipole type.

(b) The set CDDFGN of Ref.[17] used in the analysis of Deandrea et al [9], where the normalization of the heavy to light transition form factors at zero momentum transfer has been estimated in a model combining chiral and heavy quark symmetry with

mass corrections. The pole masses are as in Ref.[8] and a monopole type is used for all form factors.

(c) The set PB as suggested by Ref.[18], where $A_1^{B\rho}$ is constant (here we use $A_1^{B\rho} = 0.45$), $V^{B\rho}$ has a monopole type with pole mass 6.6 GeV and $V^{B\rho}(0) = 0.6$ and $A_2^{B\rho}$ is assumed to be rising slowly and parameterized as in Ref.[19]

$$\frac{A_2^{B\rho}(m_{D^*}^2)}{A_2^{B\rho}(0)} = 1 + 0.0222 \frac{m_{D^*}^2}{GeV^2} \quad (16)$$

with $A_2^{B\rho}(0) = 0.4$.

The colour-suppressed amplitudes for the three polarization states are given by

$$\begin{aligned} \mathcal{B}_{LL}(q^2) &= \frac{f_{D^*}}{m_B} \left(\frac{1+t}{2-t} \right) \{ (1-r_D^2-t^2) A_1^{B\rho}(m_{D^*}^2) - \frac{k^2(t^2)}{(1+t)^2} A_2^{B\rho}(m_{D^*}^2) \} \\ \mathcal{B}_{\pm\pm}(q^2) &= \frac{f_{D^*}}{m_B} r_D (1+t) \{ A_1^{B\rho}(m_{D^*}^2) \mp \frac{k(t^2)}{(1+t)^2} V^{B\rho}(m_{D^*}^2) \}. \end{aligned} \quad (17)$$

6•) The decay width in each of the three polarization states is

$$\Gamma_{\lambda\lambda}(B^- \rightarrow D^{*\rho} \rho^-) = \frac{G_F^2 m_B^5}{32\pi} |V_{cb}|^2 |V_{ud}|^2 k(t^2) |a_1 \mathcal{A}_{\lambda\lambda}(q^2) + a_2 \mathcal{B}_{\lambda\lambda}(q^2)|^2 \quad (18)$$

We now define the physical quantities which we will discuss in this paper :

(a) Longitudinal polarization.

$$\begin{aligned} \rho_L &\equiv \frac{\Gamma_{LL}}{\Gamma} = \frac{\Gamma_{LL}}{\sum_{\lambda} \Gamma_{\lambda\lambda}} \\ &= \frac{|\mathcal{A}_{LL} + \zeta \mathcal{B}_{LL}|^2}{\sum_{\lambda} |\mathcal{A}_{\lambda\lambda} + \zeta \mathcal{B}_{\lambda\lambda}|^2} \end{aligned} \quad (19)$$

(b) Left-right asymmetry in transverse polarization.

$$\begin{aligned} \mathcal{A}_{LR} &\equiv \frac{\Gamma_{--} - \Gamma_{++}}{\Gamma_{--} + \Gamma_{++}} \\ &= \frac{|\mathcal{A}_{--} + \zeta \mathcal{B}_{--}|^2 - |\mathcal{A}_{++} + \zeta \mathcal{B}_{++}|^2}{|\mathcal{A}_{--} + \zeta \mathcal{B}_{--}|^2 + |\mathcal{A}_{++} + \zeta \mathcal{B}_{++}|^2} \end{aligned} \quad (20)$$

with $\zeta \equiv a_2/a_1$.

III . Analysis

We now analyze how sensitive are the longitudinal fraction and the left-right transverse asymmetry to the magnitude and to the sign of a_2/a_1 , in the zero-width approximation and a finite-width calculation of the ρ -meson respectively.

II-a. Zero-width approximation in ρ -meson(ZW).

Within the zero-width approximation for the ρ -meson, quantities defined in Eq.(14) become :

$$q^2 \equiv m_\rho^2 \quad , \quad t = \frac{m_\rho}{m_B} \quad (21)$$

and we introduce the superscript "0" to signify quantities in the zero-width approximation.

The decay width in the three polarization states is given by :

$$\Gamma_{\lambda\lambda}^0(B^- \rightarrow D^{*o}\rho^-) = \frac{G_F^2 m_B^5}{32\pi} |V_{cb}|^2 |V_{ud}|^2 k(m_{\rho^2}) |a_1 \mathcal{A}_{\lambda\lambda}(m_\rho^2) + a_2 \mathcal{B}_{\lambda\lambda}(m_\rho^2)|^2 \quad (22)$$

1 \bullet). The longitudinal fraction in the zero-width approximation is :

$$\rho_L^0 = \frac{|\mathcal{A}_{LL}(m_\rho^2) + \zeta \mathcal{B}_{LL}(m_\rho^2)|^2}{\sum_\lambda |\mathcal{A}_{\lambda\lambda}(m_\rho^2) + \zeta \mathcal{B}_{\lambda\lambda}(m_\rho^2)|^2} \quad (23)$$

In Table 1 corresponding to each models used, we show results of the relative amount of the longitudinal polarization component ρ_L^0 corresponding to four values of ζ : $\zeta = \pm 0.25$ and $\zeta = \pm 0.20$.

Figure 2-a and 2-b illustrate the sensitivity of this quantity to the relative sign and the magnitude of $\zeta = a_2/a_1$.

ρ_L^0	HQET I				HQET II			
$\zeta = a_2/a_1$	-0.25	-0.20	0.20	0.25	-0.25	-0.20	0.20	0.25
BSW II	0.924	0.916	0.854	0.848	0.925	0.916	0.848	0.841
CDDFGN	0.913	0.909	0.854	0.846	0.908	0.904	0.851	0.844
PB	0.928	0.919	0.856	0.850	0.933	0.921	0.850	0.844

Table 1.

The longitudinal polarization fraction in the ρ -meson zero-width approximation

2 \bullet). Next, we consider the transverse left-right helicity asymmetry in the zero-width approximation :

$$\mathcal{A}_{LR}^0 = \frac{|\mathcal{A}_{--}(m_\rho^2) + \zeta \mathcal{B}_{--}(m_\rho^2)|^2 - |\mathcal{A}_{++}(m_\rho^2) + \zeta \mathcal{B}_{++}(m_\rho^2)|^2}{|\mathcal{A}_{--}(m_\rho^2) + \zeta \mathcal{B}_{--}(m_\rho^2)|^2 + |\mathcal{A}_{++}(m_\rho^2) + \zeta \mathcal{B}_{++}(m_\rho^2)|^2} \quad (24)$$

The amount of left-right asymmetry in transverse polarization, in the zero-width approximation, corresponding to values of ζ , $\zeta = \pm 0.25$ and $\zeta = \pm 0.20$, is shown in Table 2 and the sensitivity to the relative sign and the magnitude of $\zeta = a_2/a_1$ for each models is shown in Figures 3-a and 3-b.

A_{LR}^0	HQET I				HQET II			
$\zeta = a_2/a_1$	-0.25	-0.20	0.20	0.25	-0.25	-0.20	0.20	0.25
BSW II	0.489	0.562	0.819	0.833	0.753	0.789	0.910	0.916
CDDFGN	0.077	0.265	0.915	0.938	0.361	0.527	0.973	0.984
PB	0.216	0.396	0.850	0.867	0.583	0.693	0.927	0.934

Table 2.

The left-right asymmetry of the transverse polarizations
in the ρ -meson zero-width approximation

Table 1 and Figures 2-a and 2-b show that the longitudinal fraction does not depend drastically upon the form factor models in the region we consider ($|\zeta| \leq 0.3$). However, the relative difference between two points $\zeta = \pm 0.2$ or ± 0.25 reached about $6 \sim 8$ percent, which might be distinguished in future experiments.

We remark that if the longitudinal fraction is greater than 0.88, the parameter a_2 is negative and if less than 0.88, a_2 is positive.

Figures 3-a and 3-b show that the left-right helicity asymmetry fraction varied considerably model to model.

Because the value of the left-right asymmetry between two relative points varies from 0.12 to 0.86, the measurement of \mathcal{A}_{LR} would be more sensitive to the sign of ζ . In the zero-width approximation of the ρ -meson, we conclude : (i) with the HQET I model of $B \rightarrow D^*$, if \mathcal{A}_{LR}^0 is greater than 0.74, a_2 is positive and if \mathcal{A}_{LR}^0 is smaller than 0.74, a_2 is negative. (ii) with the HQET II model, if \mathcal{A}_{LR}^0 is greater than 0.87, a_2 is positive and if \mathcal{A}_{LR}^0 is smaller than 0.87, a_2 is negative.

II-b. ρ -meson Non zero-width calculation (FW).

In the above calculation, ρ -meson was assumed to have zero width which is certainly a poor approximation. The final state ρ -meson has a width of about 150 MeV , and this rather wide resonance increases the effective final-state phase space. If we take the finite ρ -width into account, we have to smear the rate given in Eq.(22) over t^2 with a Breit-Wigner measure [20] :

$$\delta(t^2 - r_\rho^2) \rightarrow \frac{1}{\pi} \frac{r_\rho \gamma_\rho}{(t^2 - r_\rho^2)^2 + r_\rho^2 \gamma_\rho^2} \equiv BW(t^2) \quad (25)$$

where we introduce the dimensionless variables : $r_\rho = m_\rho/m_B$ and $\gamma_\rho = \Gamma_\rho/m_B$, ($\Gamma_\rho = 151.5 \text{ MeV}$ is the total ρ -meson width).

The decay width in the three polarization states in Eq.(22) gets modified to

$$k(m_\rho^2) |\mathcal{A}_{\lambda\lambda}(m_\rho^2) + \zeta \mathcal{B}_{\lambda\lambda}(m_\rho^2)|^2 \\ \Rightarrow \int_{\frac{4m_B^2}{m_B^2}}^{(1-r_D)^2} dt^2 BW(t^2) k(t^2) |\mathcal{A}_{\lambda\lambda}(q^2) + \zeta \mathcal{B}_{\lambda\lambda}(q^2)|^2 \quad (26)$$

1•). In the Table 3, we tabulate the longitudinal polarization fraction, ρ_L , calculated with a finite width ρ -meson in each model. And in Figure 4-a and 4-b, we show the sensitivity of the longitudinal polarization fraction to ζ .

ρ_L (FW)	HQET I				HQET II			
$\zeta = a_2/a_1$	-0.25	-0.20	0.20	0.25	-0.25	-0.20	0.20	0.25
BSW II	0.902	0.895	0.839	0.833	0.903	0.894	0.834	0.827
CDDFGN	0.890	0.887	0.839	0.833	0.896	0.890	0.831	0.824
PB	0.899	0.893	0.843	0.838	0.903	0.894	0.837	0.832

Table 3.

The longitudinal polarization fraction in the ρ -meson finite-width calculation

2•). Table 4 shows the relative amount of the left-right asymmetry of the transverse polarization in a finite-width ρ -meson calculation. And in Figures 5-a and 5-b, we show the sensitivity to the sign and the magnitude of ζ for each model.

A_{LR} (FW)	HQET I				HQET II			
$\zeta = a_2/a_1$	-0.25	-0.20	0.20	0.25	-0.25	-0.20	0.20	0.25
BSW II	0.528	0.580	0.796	0.810	0.763	0.789	0.893	0.899
CDDFGN	0.200	0.341	0.886	0.909	0.460	0.580	0.954	0.965
PB	0.350	0.462	0.827	0.843	0.656	0.721	0.909	0.917

Table 4.

The transverse left-right asymmetry in the finite-width ρ -meson calculation

As seen from Figures 4 and 5, both the longitudinal polarization fraction and the transverse left-right asymmetry vary more smoothly in the finite-width ρ -meson calculation than in the zero-width one, due to the smearing effect. For a finite width ρ -meson, a_2 has a positive value if the longitudinal polarization fraction is less than 0.86 and negative if the longitudinal polarization fraction is greater than 0.86.

As for the transverse left-right asymmetry, our results show that if \mathcal{A}_{LR} is greater than 0.86, a_2 is positive and if \mathcal{A}_{LR} is smaller than 0.72, a_2 is negative, depending on heavy to heavy transition form factor models considered.

III Discussion

1•). As shown in Figures 4 and 5, we find that the smearing effect of a finite-width ρ -meson is considerable : The longitudinal component of the decay width is changed about 15% and the transverse components of decay width are changed by more than 20%. The longitudinal fraction is shifted by about 2% and varies more smoothly than for a zero-width ρ -meson. The left-right asymmetry of the transverse polarization is much more affected by the smearing effect as shown in Figures 5-a and 5-b.

2•). The longitudinal fraction ρ_L for reasonable value of ζ is only weakly model dependent. In the non-zero ρ -meson width calculation we obtain the following results :

1) If ρ_L is large, $\rho_L > 0.86$, negative values of a_2/a_1 are favoured and for $\rho_L < 0.86$, positive values emerge. We must keep in mind that the value $\rho_L = 0.86$ at $a_2 = 0$ depends only on the spectator amplitude or equivalently of the heavy to heavy transition and it is more reliable.

2) The model dependence of ρ_L is moderate : for instance with $a_2/a_1 = 0.2$ we obtain $\rho_L = 0.831 - 0.843$ from Table 3, for $a_2/a_1 = -0.20$, we get $\rho_L = 0.887 - 0.895$.

3•). The transverse left-right asymmetry \mathcal{A}_{LR} appears to be more model dependent than ρ_L especially for negative a_2/a_1 . In the non-zero ρ -meson width calculation the results are the following :

1) If \mathcal{A}_{LR} is larger than 0.72 with HQET I and 0.86 with HQET II, positive values of a_2/a_1 are favoured. Figures 5-a and 5-b also depend only on heavy to heavy transition and are reliable even if the model dependence is more important than for ρ_L .

2) For a_2/a_1 positive the model dependence remains moderate. For instance with $a_2/a_1 = 0.2$ we obtain, from Table 4, $\mathcal{A}_{LR} = 0.796 - 0.954$. However for a_2/a_1 negative, the model dependence is very important and at $a_2/a_1 = -0.2$ we obtain $\mathcal{A}_{LR} = 0.341 - 0.789$. With very large negative value of a_2/a_1 , \mathcal{A}_{LR} may even become negative.

4•). We would like to emphasize the difference between our approach and the ones adopted by others [1, 4, 6, 7]. These authors determine the size and the sign of a_2/a_1 from a global fit to the ratios of Class III to Class I rates as defined in [1, 4, 6, 7]. In our approach, we propose to determine the magnitude and the sign of a_2/a_1 by using the sensitivity of the longitudinal polarization fraction and the left-right asymmetry in transverse polarization fraction of Class III process alone.

Therefore measurements of the longitudinal polarization fraction and the transverse left-right helicity asymmetry of $B^- \rightarrow \rho^- D^{*0}$ decay mode seem to be important.

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Figure captions

1. **Fig. 1 :** Feynman diagrams for $B^- \rightarrow D^{*o}\rho^-$ decay.
 - (a) external spectator diagram.
 - (b) internal spectator (colour-suppressed) diagram.
2. (a) **Fig. 2-a :** The longitudinal polarization fraction Γ_L/Γ in $B^- \rightarrow D^{*o}\rho^-$ decay within zero-width approximation for the ρ meson,
 - (1) the solid line corresponds to BSW II model in $B \rightarrow \rho$ transition,
 - (2) the dotted line corresponds to CDDFGN model in $B \rightarrow \rho$ transition,
 - (3) the dash-dotted line corresponds to PB model in $B \rightarrow \rho$ transition with HQET I model in $B \rightarrow D^*$ transition.

(b) **Fig. 2-b :** Same as Fig. 2-a with HQET II model in $B \rightarrow D^*$ transition.
3. (a) **Fig. 3-a :** The left-right helicity asymmetry of the transverse polarization fraction \mathcal{A}_{LR} in $B^- \rightarrow D^{*o}\rho^-$ decay within zero width approximation for the ρ meson.
 - (1) the solid line corresponds to BSW II model in $B \rightarrow \rho$ transition.
 - (2) the dotted line corresponds to CDDFGN model in $B \rightarrow \rho$ transition.
 - (3) the dash-dotted line corresponds to PB model in $B \rightarrow \rho$ transition with HQET I model in $B \rightarrow D^*$ transition.

(b) **Fig. 3-b :** Same as Fig. 3-a with HQET II model in $B \rightarrow D^*$ transition.
4. **Fig. 4-a and 4-b :** Same as Figures 2-a and 2-b with the finite-width ρ meson.
5. **Fig. 5-a and 5-b :** Same as Figures 3-a and 3-b with the finite-width ρ meson.

Table captions

1. **Table 1 :**

The longitudinal polarization fraction Γ_L/Γ in $B^- \rightarrow D^{*o}\rho^-$ decay at $a_2/a_1 = -0.25, -0.20, 0.20$ and 0.25 with HQET I, HQET II models for $B \rightarrow D^*$ transition and BSW II, CDDFGN, PB models for $B \rightarrow \rho$ transition with the zero-width ρ meson.

2. **Table 2 :**

The left-right asymmetry of the polarization fraction \mathcal{A}_{LR} in $B^- \rightarrow D^{*o}\rho^-$ decay at $a_2/a_1 = -0.25, -0.20, 0.20$ and 0.25 with HQET I, HQET II models for $B \rightarrow D^*$ transition and BSW II, CDDFGN, PB models for $B \rightarrow \rho$ transition with the zero-width ρ meson

3. **Table 3 :**

The longitudinal polarization fraction Γ_L/Γ in $B^- \rightarrow D^{*o}\rho^-$ decay at $a_2/a_1 = -0.25, -0.20, 0.20$ and 0.25 with HQET I, HQET II models for $B \rightarrow D^*$ transition and BSW II, CDDFGN, PB models for $B \rightarrow \rho$ transition with the finite-width ρ meson.

4. **Table 4 :**

The left-right asymmetry of the polarization fraction \mathcal{A}_{LR} in $B^- \rightarrow D^{*o}\rho^-$ decay at $a_2/a_1 = -0.25, -0.20, 0.20$ and 0.25 with HQET I, HQET II models for $B \rightarrow D^*$ transition and BSW II, CDDFGN, PB models for $B \rightarrow \rho$ transition with the finite-width ρ meson.